# AIR QUALITY MODEL GUIDELINE

Government of Alberta

# Air Quality Model Guideline

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# PREFACE

The Alberta Environment (AENV) Air Quality Modelling Guideline (Guideline) is intended for operations and proposed operations that require an *Environmental Protection and Enhancement Act* (EPEA) approval or that operate under a Code of Practice for emissions to the atmosphere.

AENV has developed the Guideline to ensure consistency in the use of dispersion models for regulatory applications in Alberta. The practices recommended within this Guideline are a means to ensure that these objectives are met.

The Guideline outlines AENV's dispersion modelling requirements and methods. Although some specific information on models is given, the user should refer to user guides and reference materials for the model of interest for further information on dispersion modelling. The Guideline will be reviewed regularly to ensure that the best available tools are being used to predict air quality.

Additional information relevant to dispersion models can be located at these web pages:

- http://www.environment.alberta.ca/622.html
- http://www.environment.alberta.ca/623.html
- http://www.epa.gov/scram001

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# 1.0 INTRODUCTION

This Guideline provides detailed guidance on suitable methods and approaches that should be used to assess air quality from emission sources. It sets out:

- the statutory authority;
- an overview of the approach;
- guidance on appropriate technical methods, and
- the information required to demonstrate that a source meets the Alberta Ambient Air Quality Objectives (AAAQO).

It is not intended to provide a technical description of the theory behind dispersion modelling - such information is widely available in other published documents, and references are provided within the text.

Detailed advice on the types and uses of dispersion models is provided in Sections 2 to 4. Section 5 provides guidance on the application of regulatory models, describing individual models and their intended uses. Section 6 gives Internet addresses for a variety of modelling resources. Section 7 provides some information about regional modelling in the Province. Appendix A lists the contents of screening assessments expected by AENV. Appendix B lists the expected contents of refined and advanced assessments. There are a key number of technical skills and competencies required to perform air dispersion modelling. These competencies are outlined in Appendix C.

## 1.1 Purpose of the Air Quality Modelling Guideline

AENV has developed the Air Quality Modelling Guideline to ensure consistency in the use of dispersion models in air quality assessments. The objectives are to:

- provide for uniform benchmarking,
- provide a structured approach to selection and application of models,
- ensure that there is a sound scientific basis for the use of alternatives, and
- detail the required content of assessments submitted to the department.

Sections 2 to 5 of the Guideline address only primary substances directly emitted from a source. Some substances are formed in the atmosphere as a result of the interaction of these primary substances with substances from either natural or industrial sources. These are known as secondary substances (e.g., secondary particulate, acid deposition and ozone). Concentrations of secondary substances must be estimated by other means acceptable to AENV as described in Section 6.

## 1.2 Statutory Authority

This Guideline is issued by AENV, under Part 1, 14 (4), the *Environmental Protection and Enhancement Act, 1992* (EPEA). This document replaces all previous versions of the Alberta Air Quality Model Guidelines.

This Guideline should be read in conjunction with the AAAQO and the Air Monitoring Directive, AENV 2006, as amended.

## 1.3 Air Quality Models

AENV works with Albertans to protect and enhance the quality of the air through a regulatory management approach that includes:

- air quality models,
- ambient air quality objectives,
- atmospheric emission inventories,
- source emission standards,
- approvals,
- environmental reporting,
- ambient air quality monitoring,
- source emission monitoring,
- inspections/abatement, and enforcement, and
- research.

Information from emission inventories and source controls are utilized in air quality modelling to relate the resulting ambient air quality to the ambient air quality objectives. Ambient monitoring determines the actual air quality resulting from the emissions.

The purpose of a dispersion model is to provide a means of calculating ambient ground-level concentrations of an emitted substance given information about the emissions and the nature of the atmosphere. The amount released can be determined from knowledge of the industrial process or actual measurements. However, predictive compliance with an ambient air quality objective is determined by the concentration of the substance at ground level. Air quality objectives refer to concentration in the ambient air, not in the emission source. In order to assess whether an emission meets the ambient air objective it is necessary to determine the ground-level concentrations that may arise at various distances from the source. This is the function of a dispersion model.

A dispersion model is a set of mathematical relationships or physical models, based on scientific principles that relate emission rates of an air contaminant to the resulting ambient concentrations. Model predictions are useful in a wide variety of air quality decisions, including determining appropriateness of facility location, monitoring-network design, and stack design. Models also provide information on the areas most influenced by emissions from a source, the contribution of weather to observed trends, and the air quality expected under various scenarios. Dispersion modelling requires knowledge of emission rates and the local meteorology and topography.

## 1.4 Levels of Modelling

The choice of dispersion model depends on a number of factors. There is a wide range of models available, and it is important that the user selects the model that fits the demands of the task. Generally, there are three levels of assessment:

1. Screening assessment is utilized to determine a specific event or the likelihood of a specific event. Screening assessments are a simple and quick way to estimate a "worst-case" concentration; however, in some cases the screening models may not provide the worst case ground level concentrations.

2. Refined assessment, because of its higher level of sophistication, more closely estimates actual air quality impacts.

3. Advanced assessment treats specific dispersion processes in greater detail. It potentially gives more accurate results but requires more input data. The user must be careful to ascertain whether the selected dispersion model is being applied to a situation for which the model was designed.

# 2.0 MODELLING PROTOCOL

A dispersion model is a series of equations describing the relationships between the concentration of a substance in the atmosphere arising at a chosen location, the release rate, and factors affecting the dispersion and dilution in the atmosphere. The model requires information on the emission characteristics (see Section 3.1) and the local meteorology (see Section 3.2). Modelling can also be used to predict future scenarios, short-term episodes, and long-term trends.

Nearby buildings and complex topography can have significant effects upon the dispersion characteristics of a plume. Buildings may cause a plume to come to ground much closer to the stack than otherwise expected, causing significantly higher substance concentrations. Plumes can impact directly on hillsides under certain meteorological conditions, or valleys may trap emissions during low-level inversions.

A hierarchy of commonly used dispersion models has been established, categorizing the models according to how they might be used within the assessment process. For example, 'screening' models are used as a benchmark or an initial step of the review, and refined models for more detailed analysis. Advanced models may be needed, depending upon the type of source(s) being studied and the complexity of the situation.

## 2.1 Modelling Decisions

All proposed emissions to the atmosphere that are subject to an EPEA approval from AENV or that operate under a Code of Practice are subject to the appropriate modelling which includes background assessment (see Section 4.2). The flow chart for modelling categories is shown in Figure 1.

For other types of facilities, the dispersion models outlined in this Guideline or equivalent ones developed or applied in consultation with AENV may be used to demonstrate compliance with the AAAQO.

When a renewal or an amendment is required for existing facilities, an assessment using the current models must be submitted for benchmarking. The flow chart for the assessment is shown in Figure 2.

Further modelling may be required at the discretion of the Director, if

- the screening modelling predicts exceedance of AAAQO,
- there are many other emission sources in the area,
- the area contains sensitive receptors,
- changes in emissions are expected at the facility, or
- there are other situations deemed necessary to be considered by the Director

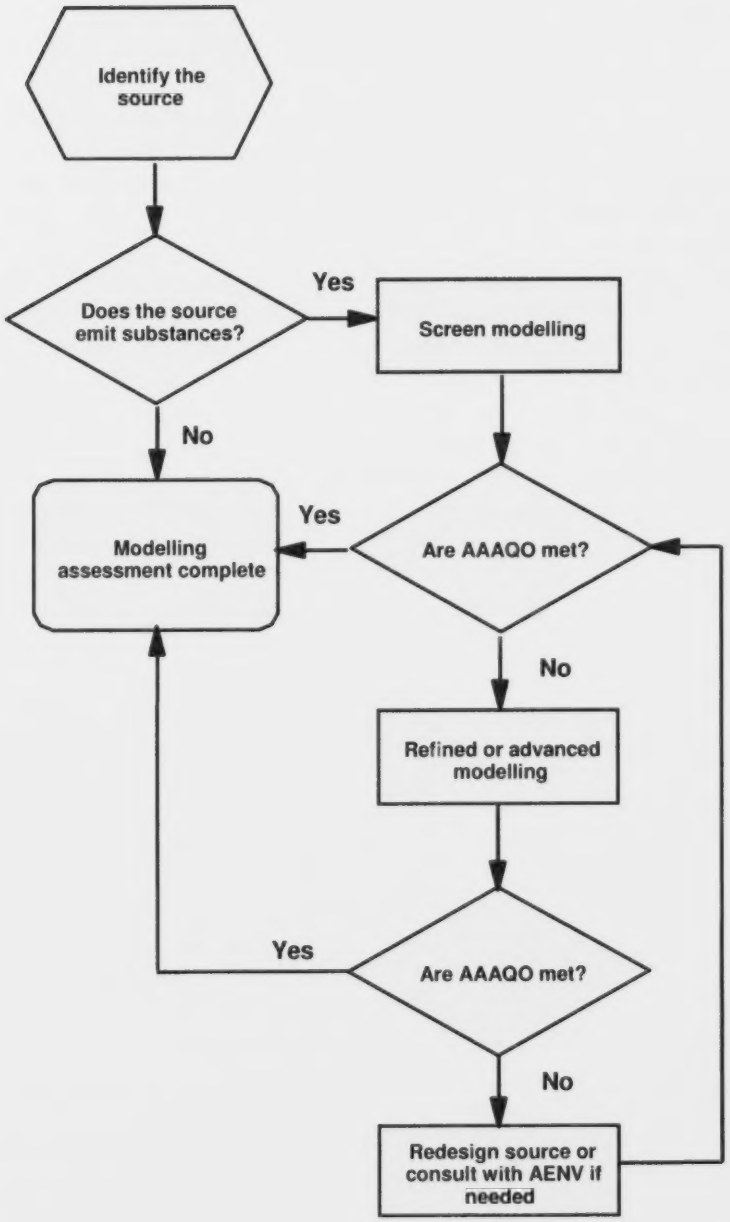


**Figure 1.** **Flow chart indicating situations in which different categories of dispersion models might be used.**

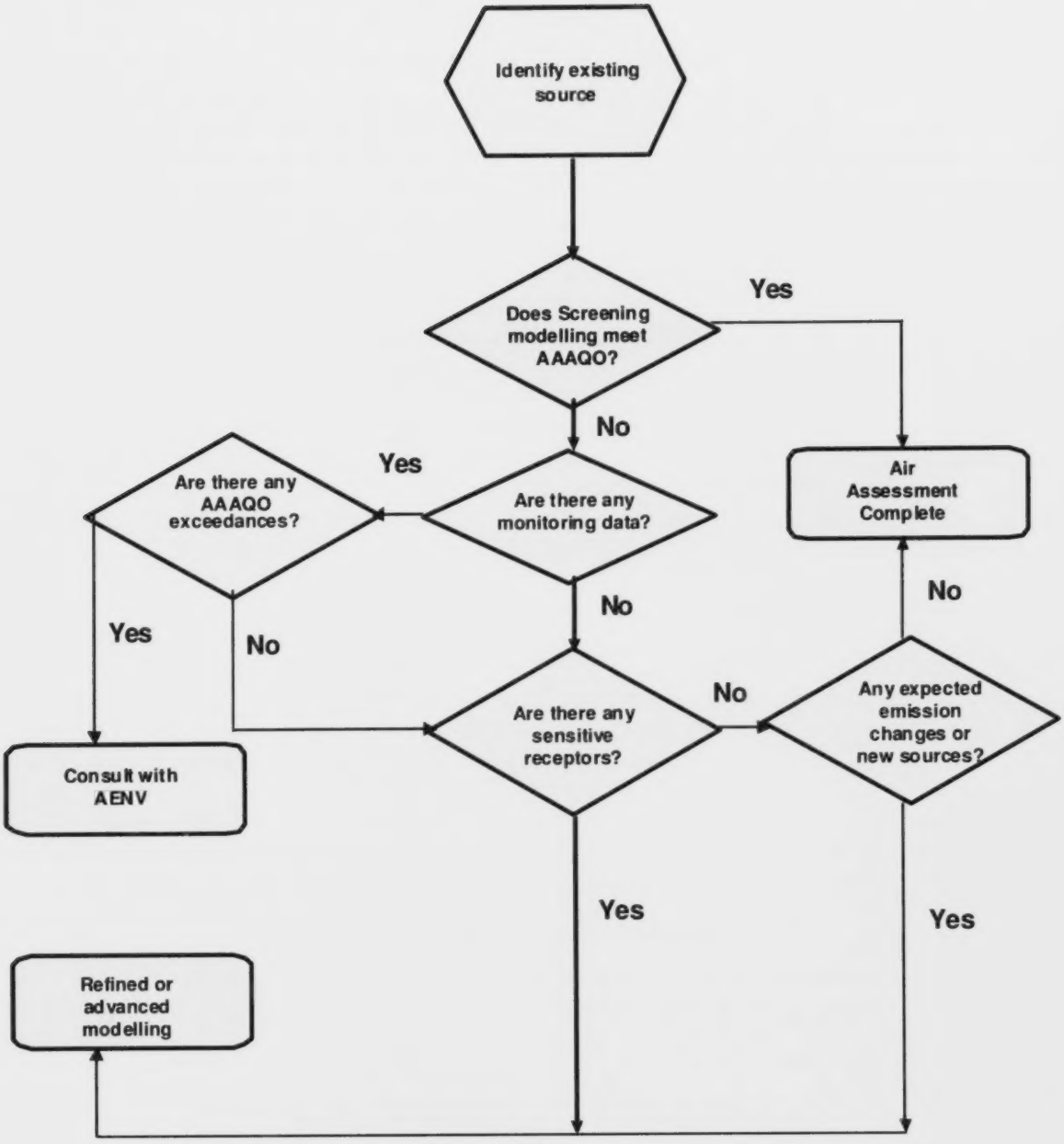


**Figure 2.** **Flow chart indicating dispersion modelling situations for renewal or amendment of approval for existing facility.**

## 2.2 Screening Model

The first tier of evaluation for single- or multiple-source impact employs a screening method using SCREEN3. The screening model results serve as benchmark for each type of source and for comparison against other sources.

In order to simplify the running of the computer model, SCREEN3 already has preset meteorological conditions included within it. There is then no need to consider local meteorology. The model will calculate worst-case concentrations and may provide the user with information on the meteorological conditions that gave rise to these concentrations.

SCREEN3 quickly gives an initial impression of the highest concentrations that are likely to occur. SCREEN3 can only treat one source at a time, however, if multiple sources are not further than 500 m apart or at different elevations, the sources can be modelled separately, and the maximums (regardless of location) should be totalled. In such an approach building downwash needs to be assessed carefully. SCREEN3 has limited capability for calculating averaging periods other than the hourly. Multiplication factors can be applied to conservatively estimate 24-h and annual averaging periods as discussed in the *SCREEN3 Model User's Guide*, (U.S. EPA, 1995) and *Screening Procedures for Estimating the Air Quality Impact of Stationary Sources (Revised)* (U.S. EPA, 1992b).

If concentrations, after adding the background, are below the AAAQO, it is usually unnecessary to undertake further modelling (see Section 4.2). Figure 3 shows the flow chart for the screening level.

## 2.3 Refined Models

The second tier or refined assessments are required to address the impacts of single or multiple sources, if any of the following conditions apply: :

- The screening assessment predicts exceedances of AAAQO;
- The area is environmentally sensitive (e.g., a national park); and/or
- Public concerns need to be addressed.

Brief descriptions of the regulatory refined models are presented in Section 5.2 (See Section 4 for output interpretation).

## 2.4 Advanced Models

For an advanced assessment using an alternative or modified model, details should be verified with AENV prior to submission. Brief descriptions of the rationales for using advanced modelling are presented in Section 5.3.

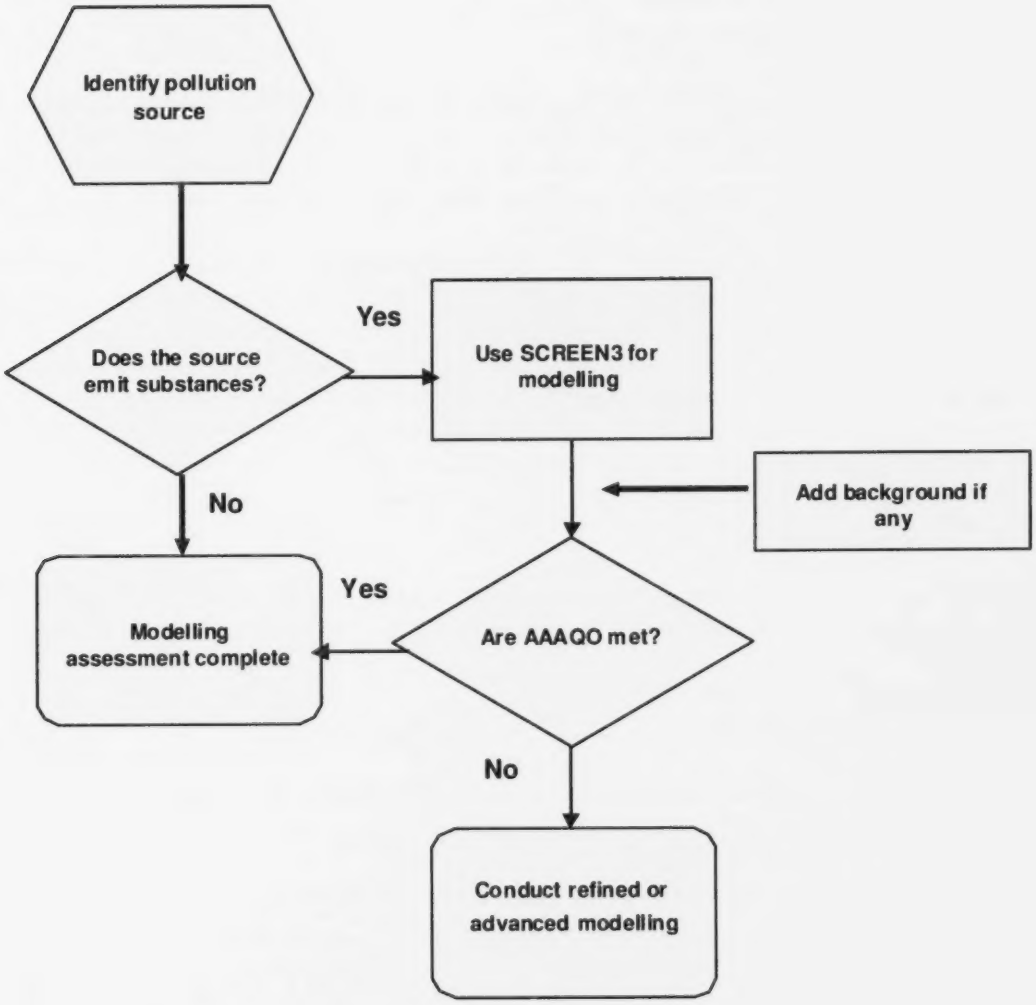


**Figure 3.** **Flow chart for screening modelling tier.**

# 3.0 INPUT DATA

All dispersion models require some form of input data that describe how much substance material is being released, details on how the substance is being released, and the environment into which the release occurs. It is also necessary to define the locations at which the impact of the emissions is to be predicted; these are termed 'receptor' locations.

The accuracy of the data input to the model has a significant effect on the accuracy of the predicted concentrations. Where the model assumes that the emissions are not chemically transformed in the atmosphere (except for CALPUFF), the predicted concentration is directly proportional to the emission rate, i.e., if the emission rate is doubled, the predicted concentration also doubles. This relationship follows regardless of how simple or sophisticated the dispersion model is. The collation of accurate emissions data is therefore extremely important and proper QA/QC procedures should be undertaken.

## 3.1 Source Input Data

Different source types are defined as follows:

- ***Point sources*** are localized sources such as stacks or flares. The source parameters normally required for point sources include the UTM or grid coordinates, release height (i.e., stack height), exit velocity, stack diameter, exit temperature and mass emission rates of the contaminants of concern.

- ***Line Sources*** are sources where emissions are in linear form such as roadsand rail lines Parameters normally required for line sources include the dimensions of the line and the mass emission rates.

- ***Area sources*** are clusters of point or line sources (e.g., fugitive emissions from industrial processes having numerous vents). Parameters normally required for area sources include the coordinates of the area perimeter, the release height, and the mass emission flux rate of the substance of concern (i.e., mass emission rate per unit of area, $g/s.m^2$).

- ***Volume sources*** are three-dimensional sources such as area sources distributed with a vertical depth, for example, emissions from lagoons. Parameters normally required for volume sources include the coordinates of the volume dimensions and the mass emission rates.

The selection of emission rates for input to the model depends on the type of model and the purpose for which the model is being used. When using models for stack design the maximum approved emission rates should be used for hourly and daily averaging periods. However, when the model is used to predict annual average concentrations, average emission rates will be adequate for the purpose.

For areas with multiple facilities, the emissions of all of the other sources in the airshed should be included. Stack parameters from existing facilities can be determined from approval limits, Continuous Emission Monitoring Systems (CEMS) conducted according to the *CEMS Code* (AENV, 1998), or manual stack surveys conducted according to the *Alberta Stack Sampling Code* (AENV, 1995). In some cases it is not practical to conduct manual stack surveys, so emission factor estimates from published sources can be used (manufacturer specifications or AP-42) (U.S. EPA, 1995a).

If sources operate only during specified hours, the modelling analysis can be restricted to the hours of operation. If this type of assessment is selected, special approval conditions may apply to restrict the operation to the time periods that were modelled.

Continuous and non-routine flares should always be designed in conformance with the most current guidelines and standards recommended by AENV or the Alberta Energy Resource Conservation Board. Non-routine flares should be modelled and assessed using guidance from the most current version of the "*Emergency/Process Upset Flaring Management: Modelling Guidance*", AENV, 2003, as amended. The ERCBFlare and ERCBIncin spreadsheets are acceptable modelling tools for the intended purposes of planned temporary flaring or incinerating.

If the stack emissions contain large particles (greater than about 40 □m in diameter), information relating to the particle size distribution may also be required.

Fugitive sources are often difficult to characterize since their emissions may vary with wind speed and time of day (for particle emissions) or process changes. AP-42 emission factors can be used to estimate fugitive emissions.

## 3.2 Meteorological Data

Since the SCREEN3 model handles only a single source at a time, wind direction is not a factor in determining worst-case conditions in flat terrain in the case where buildings do not exist. For multiple-source combinations, use of a variety of wind directions is important.

For refined assessments, actual near-site data are used. The representativeness of the actual data depends on the proximity of the meteorological monitoring site to the activity, the complexity of the terrain, the exposure of the instruments, the time of data collection, and the data recording method (Hoffnagle et al., 1981; Nappo et al., 1981; Walmsley & Bagg, 1978). Data for refined modelling must be shown to be temporally and spatially representative of the site of the facility. One of the following meteorological data sets, listed by preference, should be used in a refined assessment.

- A minimum of 1 year of site-specific meteorology. Site-specific data must be related to the longer term (seasonal or annual) by statistical methods. Relating site-specific meteorology to data from climate or meteorological stations having longer collection periods ensures that site data are temporally representative. The upper air sounding data should be taken from the most representative or closest upper air monitoring station.

- The most recent 5 years of meteorological data, readily available from a nearby airport station, that has similar site surface characteristics must be utilized. When using airport meteorological data in refined modelling, studies have shown that at least 5 years of data must be used to obtain stable distributions (U.S. EPA, 2005). If 5 years of consecutive data is not available, it is acceptable to use any 5 years of data provided they display stable distributions. The data can be purchased from Environment Canada's Meteorological Service (available at: http://climate.weatheroffice.ec.gc.ca/Welcome_e.html).

- AENV developed Fifth Generation NCAR/Penn State Mesoscale Model version 3.5 (MM5) meteorological data for all of Alberta, for 2002-2006. AENV developed an extraction utility software to extract meteorological data from the MM5 data to run AREMET and CALPUFF. The data, and the extraction utility, are available on the ftp://www.albertamm5data.com/mm5_files/ FTP site. Supporting documentation for the data sets can be found in *Development of a Multi-Model Extraction Utility & Alberta Meteorological Data Set* (AENV, 2006( and *Multi-Model Extraction Utility (MMEU) & 2002–2006 Alberta Meteorological Data Set* (AENV, 2009). Five years of extracted MM5 data are to be used for refined modelling.

The default US EPA model options should be used for CALMET modelling applications. If deviation from the default model options is required, provide justification to AENV.

An assessment to determine whether this data is adequately representative will involve an examination of the surrounding terrain, surface characteristics, and the height of the source versus the height of the measurements. Meteorological data should be considered representative only when the monitoring site and the facility site are in climatologically similar regimes (U.S. EPA 2000).

Missing meteorological data must be processed prior to being utilized in a model. There are numerous methods of processing missing data. Generally:

- A data set should not be used if fewer than 90% of the annual data are available.
- When missing data values arise, they should be handled in one of the ways listed below, in the following order of preference (U.S. EPA, 2000):
    1. If there are other on-site data, such as measurements at another height, they may be used when the primary data are missing and corrections based on established vertical profiles should be made. Site-specific vertical profiles based on historical on-site data may also be appropriate to use after consultation with AENV.
    2. If there are only one or two missing hours, linear interpolation of missing data may be acceptable, however, caution should be used when the missing hour(s) occur(s) during day/night transition periods.
    3. If representative off-site data exist, they may be used. In many cases, this approach is acceptable for cloud cover, ceiling height, mixing height, and temperature.
- Consult with AENV regarding substitution of data for longer periods, or if insufficient data is available. For these cases, shorter periods or appropriate substitution of data can be used with approval from AENV.

## 3.3 Surface Characteristics

Surface characteristics determine the degree of ground turbulence caused by the passage of winds across surface structures. The following method is to be used for selecting the rural or urban surface roughness category for screening assessments.

Classify the land use within a 3-km radius of the source. If more than 50% of the land use falls within the following categories—heavy or light industrial, commercial, and compact residential (two-story dwellings, limited lawn sizes)—it is considered to be urban. Otherwise, use the rural coefficients by selecting rural roughness, except for forests, which are treated as urban locations.

The input for the AERMET meteorological processor of AERMOD requires surface roughness, Bowen ratio and Albedo parameters. Although there are default values for surface roughness, the monthly values should be used if available. When monthly data is unavailable, a representative value can be selected based on the land use type as a function of season within a 3 km radius of the input meteorological data (Table 1).

The EPA released AERSURFACE in 2008, a utility to obtain realistic and reproducible surface characteristics using US land cover datasets. Unfortunately, these datasets do not cover Canada. Tables 1 through 3 are the minimum recommended requirements of the department; however, if modellers see the necessity to implement the recommendations in the *AERMOD Implementation Guide* (USEPA, 2008) for determining surface characteristics, justification should be provided to AENV.

**Table 1. Surface Roughness Length (m) for Land Use and Seasons (Paine, 1987)**

| Land Use Type | Spring | Summer | Autumn | Winter |
|---|---|---|---|---|
| Water (fresh water and sea water) | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Deciduous Forest | 1.00 | 1.30 | 0.80 | 0.50 |
| Coniferous Forest | 1.30 | 1.30 | 1.30 | 1.30 |
| Swamp | 0.20 | 0.20 | 0.20 | 0.05 |
| Cultivated Land | 0.03 | 0.20 | 0.05 | 0.01 |
| Grassland | 0.05 | 0.10 | 0.01 | 0.001 |
| Urban | 1.00 | 1.00 | 1.00 | 1.00 |
| Desert Shrubland | 0.30 | 0.30 | 0.30 | 0.15 |

Definition of Seasons:
"Spring" refers to periods when vegetation is emerging or partially green. This is a transitional situation that applies for 1–2 months after the last killing frost in spring.
"Summer" applies to the period when vegetation is lush and healthy, typical of midsummer, but also of other seasons where frost is less common.
"Autumn" refers to a period when freezing conditions are common, deciduous trees are leafless, crops are not yet planted or are already harvested (bare soil exposed), grass surfaces are brown, and no snow is present.
"Winter" conditions apply for snow-covered surfaces and subfreezing temperatures.

Albedo and Bowen Ratio values can also be chosen to appropriately represent particular site conditions. Tables 2 and 3 provide Albedo and Bowen Ratio values as a function of land use and season (Paine, 1987).

**Table 2. Albedo of Land Use Types and Seasons (Paine, 1987)**

| Land Use Type | Spring | Summer | Autumn | Winter* |
|---|---|---|---|---|
| Water (fresh water and sea water) | 0.12 | 0.10 | 0.14 | 0.20 |
| Deciduous Forest | 0.12 | 0.12 | 0.12 | 0.50 |
| Coniferous Forest | 0.12 | 0.12 | 0.12 | 0.35 |
| Swamp | 0.12 | 0.14 | 0.16 | 0.30 |
| Cultivated Land | 0.14 | 0.20 | 0.18 | 0.60 |
| Grassland | 0.18 | 0.18 | 0.20 | 0.60 |
| Urban | 0.14 | 0.16 | 0.18 | 0.35 |
| Desert Shrubland | 0.30 | 0.28 | 0.28 | 0.45 |

**Table 3. Daytime Bowen Ratios for Land Use Types and Seasons (Average Moisture Conditions) (Paine, 1987)**

| Land Use Type | Spring | Summer | Autumn | Winter* |
|---|---|---|---|---|
| Water (fresh water and sea water) | 0.1 | 0.1 | 0.1 | 1.5** |
| Deciduous Forest | 0.7 | 0.3 | 1.0 | 1.5 |
| Coniferous Forest | 0.7 | 0.3 | 0.8 | 1.5 |
| Swamp | 0.1 | 0.1 | 0.1 | 1.5 |
| Cultivated Land | 0.3 | 0.5 | 0.7 | 1.5 |
| Grassland | 0.4 | 0.8 | 1.0 | 1.5 |
| Urban | 1.0 | 2.0 | 2.0 | 1.5 |
| Desert Shrubland | 3.0 | 4.0 | 6.0 | 6.0 |

* Winter Bowen ratios depend upon whether a snow cover is present. Bowen ratios range from the value listed for autumn for rare snow covers to the value listed for winter for a continuous snow cover.

** This value applies if water body is frozen over.

Definitions of the seasons are the same given in Table 1.

## 3.4 Local Buildings

To take account of local building effects, models generally require information related to the dimensions and location of the structures with respect to the stack. If the stack is located on the top of a building, or adjacent to a tall building, it may be necessary to consider the size of these buildings. As a general guide, building downwash problems may occur if the height of the top of the stack is less than 2 ½ times the height of the building upon which it sits. It may be necessary to consider adjacent buildings if they are within a distance of 5 times the lesser of the width or peak height from the stack (5L). This distance is commonly referred to as the building's *region of influence*. If the source is located near more than one building, assess each building and stack configuration separately. If a building's projected width is used to determine 5L, determine the *apparent width* of the building. The apparent width is the width as seen from the source looking towards either the wind direction or the direction of interest. The stack height calculation does not dictate a minimum stack height; it determines weather building sizes need to be considered to account for possible building downwash conditions.

For example, the models require the apparent building widths (and also heights) for every 10 degrees of azimuth around each source. Due to the complexity of building downwash guidance, the U.S. EPA has developed a computer program for calculating downwash parameters. The U.S. EPA Building Profile Input Program (BPIP) is designed to calculate building heights (BH's) and the *apparent width* (U.S. EPA, 1995b), and it is available from the U.S. EPA SCRAM web site. Building downwash should not be analyzed for area or volume sources. The Plume Rise Model Enhancement (PRIME) algorithm that is integrated into AERMOD and CALPUFF is the preferred method used in the models to account for building downwash.

To account for downwash, the SCREEN3 model requires the height of the building or structure and the respective maximum and minimum horizontal dimensions. Generally, include the building with dimensions that result in the greatest stack height for that source, to evaluate the greatest downwash effects. Be aware that when screening tanks, the tank diameter should not be used. The SCREEN3 model uses the square root of the sum of the squares of the width and length of a structure in order to calculate the projected width. Because most tanks are cylindrical, the projected width is constant for all flow vectors. However, using the actual tank diameter for both width and length will result in a projected width that is too large. Therefore, when screening tanks, the model user should divide the diameter of the tank by the square root of 2.

## 3.5 Selecting Receptor Grid

The user needs to define the locations at which ground-level concentrations are to be predicted. In selecting receptor locations, it is general practice to identify the nearest, sensitive locations to the stack, such as residential housing, hospitals, etc. A careful selection of receptor points should be made so that the maximum ground-level concentration is found.

Most models allow the selection of a Cartesian receptor grid, which can be regularly or irregularly spaced. Since the number of allowed receptors is limited, they should be more

densely located where maximum impacts are expected. To ensure the maximum concentrations are obtained, the model should be run with the following set of receptors:

- 20-m receptor spacing in the general area of maximum impact and the property boundary,
- 50-m receptor spacing within 0.5 km from the source,
- 250-m receptor spacing within 2 km from the sources of interest,
- 500-m spacing within 5 km from the sources of interest,
- 1000-m spacing beyond 5 km.

It is best to run the model twice, first with the coarse grid to determine the areas of impact, and then with the finer grid in the vicinity of the impacted area to obtain the maximums.

In areas with many industrial sources, or for large buoyant sources (100-m tall stacks, high exit temperature), a larger 250-m grid, and a coarse grid out to a distance of 20 km may be necessary to find the area of maximum impacts. In some cases, an even larger grid may be necessary.

The model domain for any assessment should not exceed the limitations of the model. If it is necessary to model at points beyond the model limitations, the results should be interpreted with extreme caution.

### 3.6 Terrain Situation

For SCREEN3 assessments, the terrain in the vicinity of a source can fall into two main categories as defined, based on Rowe (1982) definition, by AENV:

- Simple terrain (parallel air flow) - terrain whose elevation does not exceed 2/3 of the plume height (plume rise + stack height) at stability category F with a wind speed of 1 m/s and a flow rate of Qmax/2. The maximum terrain criteria can be calculated using spreadsheet posted on http://www.environment.alberta.ca/2478.html under model support bullet.
- Complex terrain – topography where elevations are greater than those used to define simple terrain.

In general, the larger the source, the greater the distance to which consideration of possible impacts of terrain elevations must extend. When modelling a facility using SCREEN3, terrain in the local airshed surrounding the source must be considered if (see Figure 5):

- there is any complex terrain within the modelling domain, or
- terrain elevation rises more than 50 m per 1000 m distance from the source.

Available sources of terrain data suitable for AERMOD and/or CALPUFF are (modellers should use the best available information):

- Geobase Canada provides terrain data in USGS DEM type data (Canadian Digital Elevation Data – CDED) for a 1:50,000 and a 1:250,000 map scale (NAD83). It is freely available to download from: http://www.geobase.ca. For this data note the following:

1) the 250,000 map scale data has a grid resolution range of 3 to 12 arc-seconds, depending on latitude. For data south of 68° N latitude, the grid resolution is roughly 90 m, depending on latitude. The data sheets are directly readable by AERMAP and TERREL and are equivalent to the one-degree USGS DEM data (BC Ministry of Environment, 2006).
2) the 1:50,000 map scale data has a grid resolution range of 0.75 to 3 arc-seconds. For data south of 68° N latitude, the grid resolution is roughly 20 m, depending on latitude. This data is not directly readable by AERMAP and TERREL, and must be converted to equivalent 7.5-minute USGS DEM data (BC Ministry of Environment, 2006).

- The Alberta Ministry of Sustainable Resource Development provides terrain data for Alberta (http://srd.alberta.ca/lands/geographicinformation/resourcedataproductcatalogue/provincialbasemap.aspx). The distribution of Provincial Digital Base Map Data to the public is provided by AltaLIS Ltd. The data can be ordered from the AltaLIS website at http://www.altalis.com.

- Terrain data for North America at a resolution of three arc-seconds (~90 m) up to 60° N can be freely downloaded from http://www.src.com/datasets/datasets_terrain.html#SRTM_DATA. Note that this data needs to be checked to make sure that the elevations are ground level and not tree top elevations (BC Ministry of Environment, 2006).

### 3.7 Plant Boundary

Models are typically used to predict ambient concentrations, which in turn are compared to ambient air quality objectives. The areas of applicability of the AAAQO are not defined, however, often they are applied to areas where there is public access (i.e., beyond the plant boundary). The plant boundary is determined by the facility fence line or the perimeter of disturbed area that defines where public access is restricted.

### 3.8 Study Area

The study area includes measurable effects of the Project alone and in combination with other activities. At and beyond the project study area boundary, the anticipated environmental conditions should be similar with and without the Project. The predicted ground-level concentrations (from the project) need to be about 10% of the ambient air quality objectives or background value, whichever is higher, at the boundary of the model domain (study area). The predicted maximum locates within the model domain can be used to determine the study area from air emissions. The project facility should be in the centre of the study area. All existing nearby sources within a minimum of 5 km from the project facility should be considered. A representative background value is also required to be added to the maximum predicted concentrations, for details refer to Section 4.2.

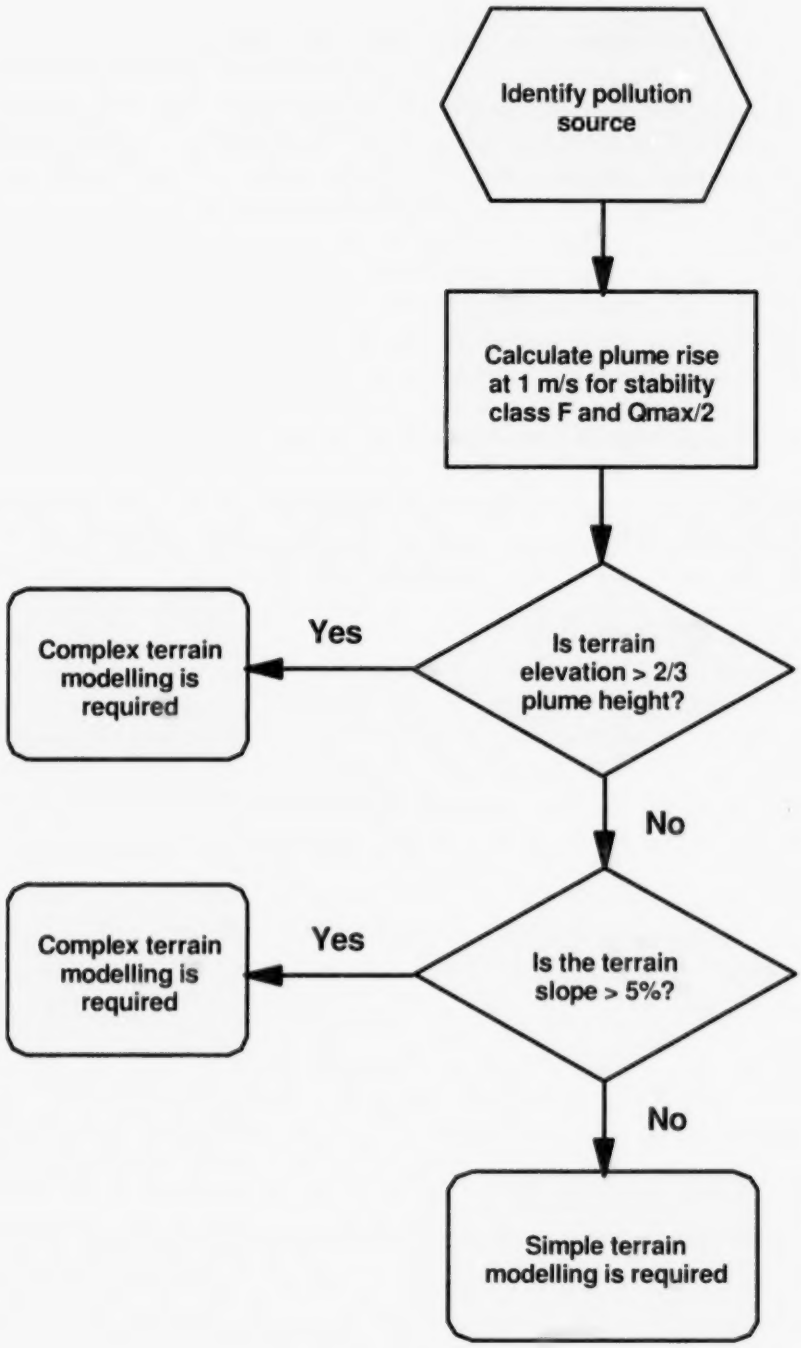
Identify pollution source
Calculate plume rise at 1 m/s for stability class F and Qmax/2
Is terrain elevation > 2/3 plume height?
Yes
Complex terrain modelling is required
No
Is the terrain slope > 5%?
Yes
Complex terrain modelling is required
No
Simple terrain modelling is required

**Figure 5.** **Flow chart for simple and complex terrain determination when using SCREEN3.**

### 3.9 Non-vertical Releases and Stacks with Rain Caps

If a point source is a non-vertical release like a horizontal flue or has a rain cap, there is no vertical velocity of the effluent emissions. CALPUFF can handle this situation through the vertical momentum flux factor; however, AERMOD is unable to do so. The following is recommended to address this issue in AERMOD (Ontario, 2005):

*V = actual stack exit velocity*
*V' = stack gas exit velocity as entered into the model*
*D = actual stack inside diameter*
*D' = stack inside diameter as input to the model*
*H = actual stack height*
*H' = stack height input to the model*

1. Set V' = 0.1 m/s or a velocity based on limiting the exit diameter to 5 times the actual diameter up to a maximum of 5 meters (see next step). This exit velocity to exit diameter rule is to avoid problems when using the PRIME algorithm.

2. Set D' = D x SQRT (V/V')

3. If the source is a vertical stack with a rain cap, account for the frequent stack tip downwash by reducing the stack height input to the model by 3 times that actual stack diameter: H' = H – 3D For horizontally oriented stacks, select no stack downwash in the model options list (if the model has this option).

# 4.0 OUTPUT INTERPRETATION

The input to dispersion models consists essentially of emissions and meteorological data. The output from dispersion models consists of concentration values. Predicted concentrations are expressed as micrograms per cubic metre ($\mu g/m^3$) of air. Concentrations of gases may also be expressed as the ratio of the volume of the substance to the volume of air. In this case, concentrations are expressed as parts per million (ppm) or parts per billion (ppb). The following equation is recommended for converting the concentrations in $\mu g/m^3$ to ppm at standard conditions ($T_{std} = 25^oC$, $P_{std} = 101.325$ kPa):

$$[ppm] * 40.8862 * \text{molecular weight} = [\mu g/m^3] \qquad (4.1)$$

## 4.1 Model Outputs

The concentration of a substance will vary from second to second because of turbulence in the atmosphere. For practical use, concentrations are expressed as averages over specified time periods. AAAQO are usually stated for 1-hour averages, 24-hour averages, and annual arithmetic averages, although other time periods are used for some substances.

For a given emission rate, predicted concentrations at ground level can be high due to extreme, rare, and transient meteorological conditions. These maximum 1-hour ground-level concentrations are considered outliers and should not be used as the basis for selecting stack height. Therefore, the highest eight 1-hour predicted average concentrations for each receptor in each single year should be disregarded. The eight highest predicted concentrations (that were disregarded for the 1-hour averaging period), must be included when calculating the 24-hour, and annual averages.

Further direction regarding the use of model outputs in Alberta is given in the document: *Using Ambient Air Quality Objectives in Industrial Plume Dispersion Modelling and Individual Industrial Site Monitoring* (AENV, 2009).

If AAAQO do not specify a value for a substance, the lesser of Ontario point-of-impingement or Texas Ambient Air Quality Guidelines concentrations should be used. If neither Ontario nor Texas has a value for the substance of interest, a risk assessment should be conducted. Contact AENV to work out details.

If maximum predicted concentrations exceed the AAAQO the applicant must contact the Director to discuss the next steps to address the predicted exceedances.

## 4.2 Background Concentrations

Background air quality includes chemical concentrations from natural sources, nearby sources, and unidentified, possibly distant sources. When conducting a screening or refined assessment, the background value (natural and industrial) for the same substance must be added to the predicted value before a comparison to the AAAQO is made. Assessing the effects of the

background component becomes more complex when short-term objectives (1-hour, 24-hour averages) are being considered. In this case, ground sources and elevated sources must be treated differently.

For example, the highest concentrations from ground sources will likely occur under calm and stable conditions during the winter. In the case of an elevated source, the weather conditions that result in the highest concentrations are convective or neutral conditions. Therefore, the addition of the maximum background concentrations to model predictions should be made under similar weather conditions.

### *4.2.1 Naturally Occurring Background*

Air quality data collected in the vicinity of the proposed source or at a representative site may be used as background values. The following method should be used to determine a background concentration:

- Generally, at least one year of monitoring data is necessary, as there are usually significant seasonal differences in ambient concentrations. This can be due to atmospheric differences or because of the seasonal nature of some operations.
- All monitoring data should be subjected to validation and quality control to ensure its accuracy.
- For 1-hour and 24-hour predicted averaging periods, the value selected for background depends on the purposes of the modelling assessment, as follows:
    - For screening assessments the 99$^{th}$ percentile value from the cumulative frequency distribution of the background monitoring data should be used.
    - For refined or advanced assessments the 90$^{th}$ percentile value from the cumulative frequency distribution of the background monitoring data should be used.
- For the annual predicted averaging period, use the 50$^{th}$ percentile from the cumulative frequency distribution of the background monitoring data.

### *4.2.2 Industrial Background*

When modelling the industrial background concentrations, within a minimum of 5 km from the facility, for 1-hour and 24-hour averaging periods, the following emission estimates should be used:

- approval limits,
- manufacturer's emission data,
- emission factors, or
- if none of the aforementioned values are available emissions can be estimated by any method approved by the department such as manual stack survey.

- For annual background values model the background sources using the average emission rate.

## 4.3 Relationship between $NO_X$ and $NO_2$

Of the several species of nitrogen oxides, only $NO_2$ is specified in the AAAQO. Since most sources emit uncertain ratios of these species and these ratios change further in the atmosphere due to chemical reactions, a method for determining the amount of $NO_2$ in the plume must be given. The recommended methods, described below, are implemented using a tiered approach as shown in Figure 6. The Total Conversion Method must be presented to AENV for all cases.

### *4.3.1 Total Conversion Method*

In this conservative screening approach, the emission rate of all $NO_X$ species is used in the dispersion model to predict ground-level concentrations of total $NO_X$. These levels of $NO_X$ are assumed to exist as 100% $NO_2$, and are directly compared to the AAAQO for $NO_2$. If the AAAQO are met, the methods in 4.3.2, 4.3.3, 4.3.4 and 4.3.5 are not necessary.

### *4.3.2 Plume Volume Molar Ratio Method (PVMRM)*

The PVMRM approach (in AERMOD) limits the conversion of NO to $NO_2$ based on the amount of ozone available within the volume of the plume. The $NO_2$/NOx conversion ratio is therefore coupled with the dispersion of the plume. The PVMRM approach also incorporates a technique for merging plumes from nearby sources for purposes of calculating the $NO_2$/NOx ratios (Hanrahan, 1999 a&b) (Alaska Department of Environmental Conservation, 2005). The following defaults are recommended:

- For background O3, use a single representative value as indicated in Table 4, or a local time series of hourly $O_3$ concentrations which match the time series of the meteorology data set period.
- If the in-stack NO2/NOx ratio is not known, use the default in-stack NO2/NOx ratio of 0.10 used in the AERMOD-PVMRM model.
- The default equilibrium ratio of NO2/NOx used in the AERMOD-PVMRM model is 0.90.

### *4.3.3 RIVAD / ARM3 Chemical Formulations in CALPUFF*

The RIVAD / ARM3 chemical formulations option in the CALPUFF model can be used to calculate $NO_2$ concentrations directly in rural (non-urban) areas (Morris et al., 1988). The RIVAD / ARM3 option incorporates the effect of chemical and photochemical reactions on the formulation of nitrates and other deposition chemicals. For background O3, use a single representative value, as indicated in Table 4, or a local time series of hourly $O_3$ concentrations which match the time series of the meteorology data set period.

### *4.3.4 Ozone Limiting Method (OLM)*

If no on-site ozone data are available, use the ozone data, shown in Table 4, based on ambient air quality monitoring data in Alberta from 1986 to 1998 (Alberta Environmental Protection 1986 – 1998; CASA, 1999).

**Table 4. AENV recommended ozone levels**

| | Urban (ppm) | Rural (ppm) |
|---|---|---|
| 1-hour average | 0.05 | 0.05 |
| 24-hour average | 0.035 | 0.040 |
| Annual average | 0.020 | 0.035 |

Using this measurement as a conservative assumption in the ozone limiting method produces the following:

Use the following equation with $[O_3] = 0.050$ ppm

If $[O_3] > 0.9*[NO_X]$ then $[NO_2] = [NO_X]$ (4.2)

otherwise $[NO_2] = [O_3] + 0.1*[NO_X]$

All concentrations in the previous equations need to be in ppm. The predicted $NO_X$ concentrations are calculated as equivalent $NO_2$.

According to Equation 4.2, if the ozone concentration is greater than 90% of the predicted $NO_X$ concentrations, all the $NO_X$ is assumed to be converted to $NO_2$. The OLM is based on the assumption that approximately 10% of the $NO_X$ emissions are generated as $NO_2$. The majority of the emission is in the form of NO, which reacts with ambient levels of ozone to form additional $NO_2$. Alternatively, if hourly ozone data are available, they can be utilized in conjunction with the hourly predictions to determine concentrations of $NO_2$.

If the period of interest is for the 24-hour or annual guideline, the model user has two options:

- The hourly predictions at each location can be ozone limited, and the averages could be used to determine the maximum 24-hour and annual concentrations. Site specific ozone data is required for this option.
- The 24-hour or annual concentration can be determined as direct output and the $O_3$ concentrations (daily and annual) in Table 1 can be utilized.

### *4.3.5 Ambient Ratio Method (ARM)*

If there is at least one year of monitoring data available for $NO_X$ and $NO_2$ within the airshed, an empirical $NO_X$ /$NO_2$ relationship can be derived and used as an alternative to the ozone limiting method. AENV must approve this approach prior to its use.

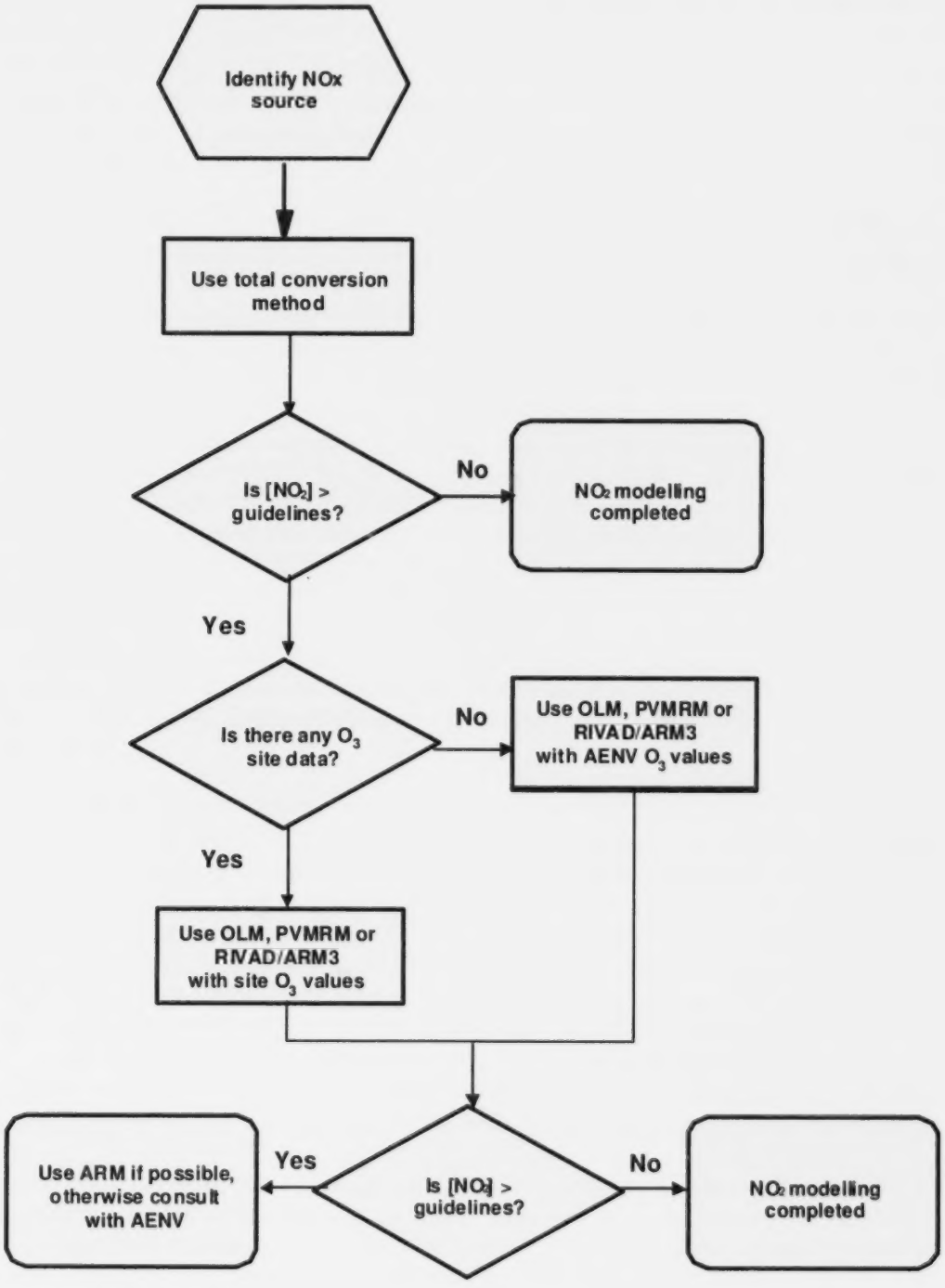


**Figure 6.** **Flow chart indicating the relationship between $NO_X$ and $NO_2$.**

# 5.0 REGULATORY MODELS

A tiered approach will save both time and money, as the aim is to progressively reduce uncertainty by moving from simple and cautious models to complex and more reliable ones, as circumstances warrant. One screening model and two refined models are recommended by AENV.

All the regulatory models are short-range. That means that only air quality within about 25 km of the source is predicted reliably, except for CALPUFF, which can be used up to 200 km.

The user of a model should be able to justify the choice of any particular model and demonstrate its 'fitness for purpose'. If a simple screening model shows that emissions from a certain process can result in concentrations that are well below the air quality objective, including background levels, more detailed modelling should not normally be necessary. Refined or advanced models need to be used if the screening predictions of ambient ground concentrations exceed the relevant air quality objectives. The choice of model is dependent on the quantity and quality of the available input data. If the screening review indicates that more refined modelling is required, representative meteorological data and more accurate emission data must be used.

## 5.1 Screening Model

- **SCREEN3 -** This U.S. EPA, PC-based model uses worst-case meteorological data. It can model a single point, area, or volume source, and can take account of building wake effects. It has a limited ability to treat terrain above stack height (U.S EPA, 1995c).

## 5.2 Refined Models

- **AERMOD-PRIME –** AERMOD was developed by the U.S. EPA (2004), in collaboration with the American Meteorological Society. This is a multi-source steady-state plume model. In the stable boundary layer (SBL), the concentration distribution is assumed to be Gaussian in both the vertical and horizontal. In the convective boundary layer (CBL), the horizontal distribution is assumed to be Gaussian, but the vertical distribution is described with a bi-Gaussian probability density function (pdf). Additionally, in the CBL, AERMOD treats "plume lofting," whereby a portion of plume mass, released from a buoyant source, rises to and remains near the top of the boundary layer before becoming mixed into the CBL. AERMOD also tracks any plume mass that penetrates into elevated stable layer, and then allows it to re-enter the boundary layer when and if appropriate.

- CALPUFF - This model is a multi-layer, multi-species, non-steady-state puff dispersion model that can simulate the effects of time- and space-varying meteorological conditions on substance transport, transformation, and removal. CALPUFF can use the three-dimensional meteorological fields developed by the CALMET model, or simple, single-station winds in a format consistent with the meteorological files used to derive steady-state Gaussian models. CALPUFF with simple single-station data (AERMOD-type) should be used with dispersion coefficients calculated using turbulence computed from micrometeorology based on

similarity theory, not Pasquill-Gifford coefficients. When dispersion modelling is conducted using the full CALPUFF model the default US EPA model options should be used for all CALPUFF modelling applications. If deviation from the default model options is required, provide justification to AENV. CALPUFF and CALMET version 6.0 or any higher version approved by the US EPA should be used.

## 5.3 Advanced Models

In some cases the particular circumstances of topography, climate, source configuration, emissions characteristics, sensitivity of receptors, local concerns, or other unusual features will require the selection of the model better suited to the situation. Regulatory models may need to be modified to reflect these unique conditions; these modifications will be accepted if they can demonstrate that they perform better than the recommended model when tested against the available air quality data. Model selection and the level of assessment to be performed can be verified by contacting AENV.

Any modification to a recommended model or any other generally available dispersion model must be supported by at least one of the following:

- a detailed observational study (field, wind tunnel, or water channel),
- theory supported by comparisons in literature,
- theory supported by comparison with on-site data.

All modified models must be shown to perform better than the regulatory model when tested against site-specific ambient monitoring data. Performance against the refined model must also be documented.

In general, a performance evaluation consists of the following (U.S. EPA, 1992a):

- accuracy of peak predicted concentrations (against site-specific air quality data),
- a correlation analysis,
- test of model precision, and
- test of model bias.

# 6.0 OBTAINING MODELS AND RESOURCES

This section contains instructions for accessing information relevant to dispersion modelling. There are two areas of information, AENV web page, and the U.S. EPA web page. The AENV home page contains general information about AENV, Alberta regulatory information, regional meteorological data sets, and updates of these model guidelines. The U.S. EPA home page has a link to its Support Centre for Regulatory Air Models (SCRAM) page.

Whenever using these dispersion models, it is the responsibility of the user to ensure that they are running the current version of the model. This is easily checked by comparing the Julian date on the model output (example "version dated 92245") with the date given in the *Listing of Model Version Numbers* section of the SCRAM site, or by contacting AENV. The use of methods and models other than the previously mentioned regulatory models should always be confirmed with AENV before proceeding.

Most of the files are in a compressed format for faster downloading. Documents and manuals are usually written with WordPerfect 5.1 format, and should be printed from this software for best results. They are also available in Adobe Acrobat format. This viewer software is available on the internet at no charge.

## 6.1 Alberta Environment Home Page

AENV has developed a home page on the internet. Browser software is necessary to view this home page. The address for this page is:

http://www.environment.alberta.ca/1.html#554

This home page contains information about air quality monitoring in the province, the Clean Air Strategic Alliance, and a section related to air quality modelling. The web address of the modelling section is:

http://www.environment.alberta.ca/622.html

These guidelines and information relating to the guidelines can be found at this address. AENV has set up an e-mail list server where information on updates and new versions of the guidelines will be sent periodically. The e-mail list is free, and instructions for signing up can be found at the above site.

http://www.environment.alberta.ca/623.html

The MM5 metrological data are also linked to this web site, and can be downloaded by following the links at the address above.

The Protection/Enforcement section contains information related to the regulatory approval process, including the EPEA and AAAQO.

## 6.2 U.S. EPA SCRAM Home Page

The SCRAM site covers topics related to dispersion models. The internet site can be accessed at the following address:

http://www.epa.gov/scram001/index.htm

## 6.3 Canadian Climate Normals

The Canadian Climate Normals are available free of charge at the following web site:

http://climate.weatheroffice.ec.gc.ca/Welcome_e.html

This information can be utilized for comparison with dispersion model results for simple cases and to compare the representativeness of site data or other meteorological data for the region. If sufficient data are available, climatological wind directions, wind speeds, and temperatures can be analyzed to determine the frequency of particular meteorological conditions. This could be compared to the worst-case modelled condition, to help determine possible frequencies of occurrence of elevated concentrations.

# 7.0 REGIONAL MODELLING

## 7.1 Acid Deposition

Figure 7 outlines the factors that shall be taken into consideration when setting up and implementing a regional management framework or completing an Environmental Assessment (EA). For regional modelling of acid deposition, CALPUFF, or any other deposition model recommended by AENV, shall be used. For further details review Alberta Acid Deposition Management Framework (AENV, March 2008) at
http://environment.gov.ab.ca/info/library/7926.pdf

To ensure that planned development in or around a region does not result in acid deposition issues, and also to guide management of acidifying emissions, a project proponent should be required to complete regional acid deposition modelling if:

- the proponent's combined emissions of $SO_2$, $NO_x$, and $NH_3$ are greater than 0.175 t/d of $H^+$ equivalent,
    - Total $H^+$ equivalent (t/d) = 2*($SO_2$ t/d)/(64)+1*($NO_x$ t/d)/(46)+1*($NH_3$ t/d)/(17)
- there is evidence that regional soil and surface water is more sensitive to acidification than is estimated in the provincial framework, or
- there is existing deposition and/or acidification impact monitoring that indicates a potential concern if acid deposition increases.

## 7.2 Ozone and Secondary Particulate Matter (PM)

For an advanced assessment or regional airshed management planning using ozone and PM model, consultation with AENV is recommended prior to application/submission. Normally, AENV would accept models developed or recommended by the US EPA. Examples of these models are: CALPUFF, California Photochemical Grid (CALGRID) model, the Models-3/Community Multiscale Air Quality (CMAQ) modelling system, the Comprehensive Air quality Model with extensions (CAMx), the Regional Modelling System for Aerosols and Deposition (REMSAD), and the Variable Grid Urban Airshed Model (UAM-V) System. These models can be obtained through the US EPA's Support Centre for Regulatory Atmospheric Modelling (SCRAM). However, preparation of input data for these models would require significant efforts.

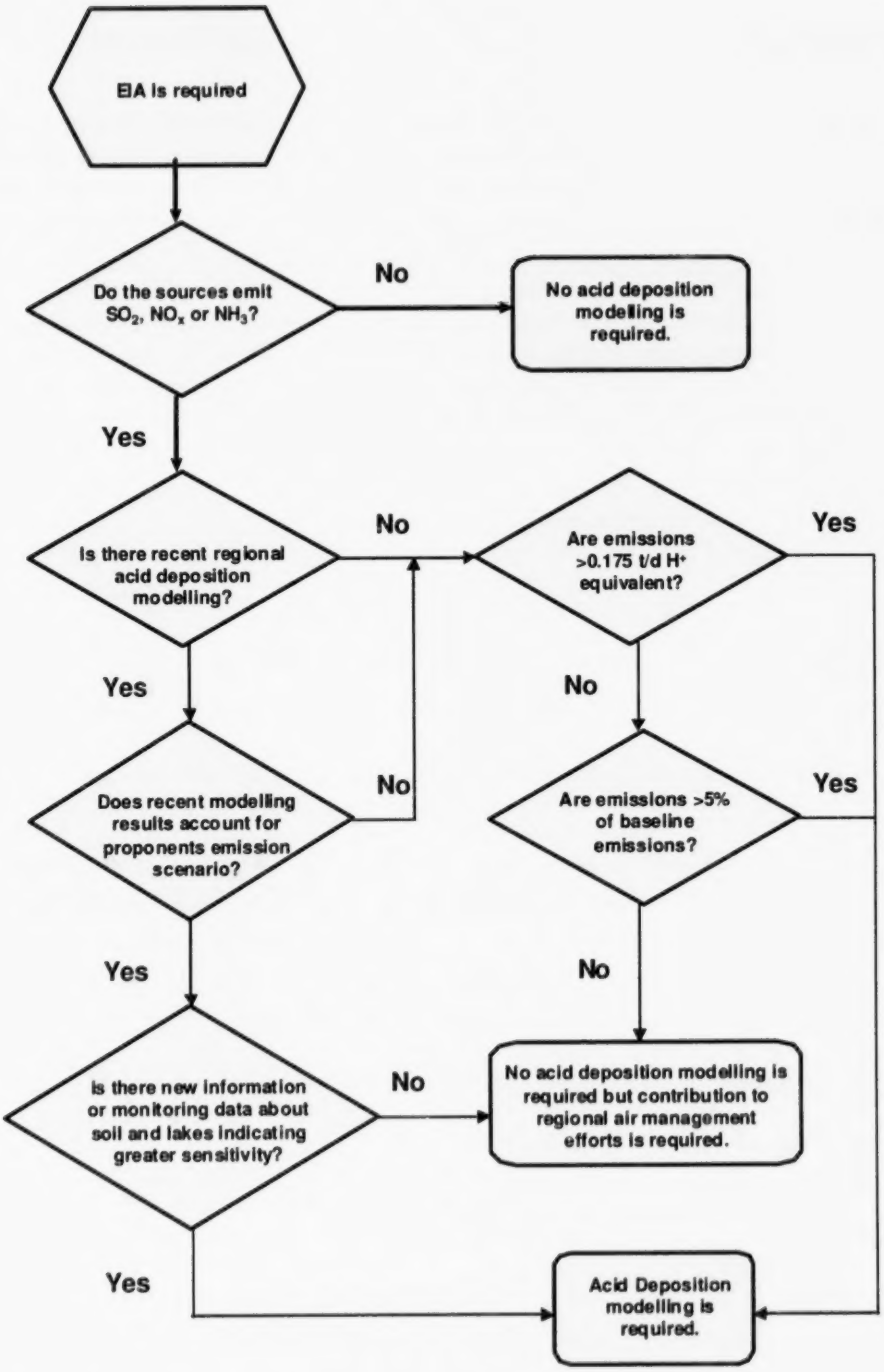
EIA is required
Do the sources emit $SO_2$, $NO_x$ or $NH_3$?
No
No acid deposition modelling is required.
Yes
Is there recent regional acid deposition modelling?
No
Are emissions >0.175 t/d $H^+$ equivalent?
Yes
Yes
No
Does recent modelling results account for proponents emission scenario?
No
Are emissions >5% of baseline emissions?
Yes
Yes
No
Is there new information or monitoring data about soil and lakes indicating greater sensitivity?
No
No acid deposition modelling is required but contribution to regional air management efforts is required.
Yes
Acid Deposition modelling is required.

**Figure 7.** **Procedural steps to determine if acid deposition modelling is required for a proposed project.**

## 8.0 CONCLUSION

This Guideline provides detailed guidance on suitable methods and approaches that should be used to assess air quality from emission sources in Alberta. The Guideline objectives are to ensure uniform benchmarking, supply a structured approach to the selection and application of models and to detail the required content of air quality assessments submitted to the department. The dispersion modelling aspects discussed in the Guideline include model input data, model output interpretation, application of regulatory models, obtaining models and resources and regional modelling in the province. The following appendices detail the expected content of screening and refined assessments as well as the competencies required to perform dispersion modelling. The practices recommended within this Guideline are a means to ensure consistency in the use of dispersion models for regulatory applications in Alberta.

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# APPENDICES

# APPENDIX A: EXPECTED CONTENT OF SCREENING ASSESSMENTS

## 1.0 Sources and Emissions

### 1.1 Source Data

- Number and type of sources (stack, flare, etc.)
- Plot plan
- Locations and dimensions of buildings (length, width, height)
- Design capacity (normal or average capacity may also be needed)

### 1.2 Characteristics of Emissions

- Chemical composition (substance type) and emission rates (g/s)
- Exit (stack) height above ground (m)
- Temperature (K) or heat content ($MJ/m^3$ and cal/s)
- Exit velocity (m/s)
- Stack top inside diameter (m)
- Other parameters if not a point source
- Calculations or explanations on how emissions were calculated

### 1.3 Potential Emissions during Abnormal Operations Start-Up or Shutdown

## 2.0 Topography

- Description and map if necessary
- Vegetation cover/land use
- Sensitive receptors nearby (public buildings, homes, etc.)

## 3.0 Results - Dispersion Model Predictions

- Summary of background air quality if available or applicable (from air quality stations - same or other facility, or appropriate AENV station)
- Building downwash (include whether effects seen on or off facility property)
- Predicted 1-hour average, 24-hour average and annual average maximums
- Comparison with existing monitoring data (if applicable)
- Soft copy of dispersion model input and output files. These may be provided in digital format (i.e., on CD).

# APPENDIX B: EXPECTED CONTENT OF REFINED AND ADVANCED ASSESSMENTS

## 1.0 Sources and Emissions

### 1.1 Source Data

- Number and type of sources (on-site and off-site)
- Plot plan
- Dimensions of nearby buildings
- Design, average and nominal capacity

### 1.2 Characteristics of Emissions

- Temperature or heat content at exit
- Exit velocity
- Stack top inside diameter (m)
- Exit height above ground
- Chemical composition and emission rates
- Water content
- Other parameters for non-point sources
- Explanations or calculations on how emissions were estimated

### 1.3 Time Variations (Short and Long-Term)

### 1.4 Potential Emissions during Abnormal Operations

- Start-up or shutdown
- Pollution control equipment failure
- Process equipment malfunction
- Damage to storage vessels
- Other accidental/unplanned emissions

### 1.5 Other Major Existing or Proposed Sources

## 2.0 Topography

- Description and map
- Elevation maxima and minima
- Vegetation cover/land use
- Receptor grid resolution and domain size
- Sensitive receptors
- Parks, campgrounds, and wilderness areas
- Population centres and public facilities
- Location of meteorological and air quality stations

## 3.0 General Climatology

- Temperature
- Precipitation
- Pressure
- Solar radiation
- Wind
- Cloud cover

## 4.0 Meteorology

- Sources of data
- Representativeness of measurements (time and space)
- Topographic influences

4.1 Wind

- Speed and direction distributions (roses)
- Relation of short-term on-site to long-term off-site
- Persistence
- Diurnal and seasonal variations
- Extreme values
- Mean speed
- Prevailing and resultant winds
- Relation to visibility restrictions
- Relation to topographic effects

4.2 Temperature

- Inversion heights, strengths, frequencies, and persistence
- Mixing layer heights, diurnal and seasonal variation
- Magnitude and behaviour, diurnally and seasonally

4.3 Turbulence

- Direct measurements - frequency distributions, diurnal and seasonal variations
- Indirect determinations, definition of stability parameter (thermal/mechanical turbulence index) and description of inference scheme
- Frequency distribution, diurnal and seasonal variations

## 5.0 Atmospheric Dispersion

- Summary of background air quality
- Contribution of sources to maximums, nearby and distant
- Building downwash
- Stack aerodynamic downwash
- Buoyancy momentum rise

- Topographic effects
- Model description and references
- Predicted hourly averages - magnitude, frequencies, duration, and timing
- Discussion of meteorology leading to highest concentrations
- Predicted daily averages
- Predicted annual averages
- Predicted depositions
- Comparisons to standards
- Expected frequency of visibility impairment due to smoke, particulate, or condensed water vapour

## 6.0 Special Topics

- Risks due to uncontrolled releases
- Unusual natural phenomena
- Atmospheric chemical transformations
- Chemical reactions between plumes containing different substances
- Synergistic effects of multiple-component emissions
- Icing caused by water vapour emissions

## 7.0 Conclusion

- Summary of impact on concentrations, depositions, visibility, and odour.
- Soft copy of the input and output files. These may be provided in digital format (i.e., on CD).
- Predicted concentration isopleths (1-hour average, 24-hour average and annual).

# APPENDIX C: COMPETENCIES FOR PERFORMING AIR DISPERSION MODELLING

## INTRODUCTION

Competencies are any attitude, skill, behavior, motive or other personal characteristic that are essential to perform a job, or more importantly, differentiate superior performers from solid performers.

The following lists the tasks and knowledge required for competent air dispersion modelling. The introductory sections- Context, Core Knowledge and Abilities, and Quality Assurance- are integral to further understanding the Task and Knowledge and Experience requirements.

## CONTEXT

The competencies must be interpreted within the following context:

- Communication with field workers, technicians, laboratories, engineers and scientists during the process is important to the success of the model.
- Record keeping is important to support the accountability of the model.

## CORE KNOWLEDGE AND ABILITIES

The modellers must have the following core knowledge and abilities, in addition to specific technical knowledge:

- Knowledge of chemical and physical meteorology.
- Understanding of the chemical and physical interactions of atmospheric pollutants.
- Knowledge of primary pollutants, and their interaction with other substances (natural or industrial) to form secondary pollutants.
- Knowledge of risks due to uncontrolled releases.
- Knowledge of legislation, regulations and guidelines in regards to Air Quality.
  - Knowledge of Air Quality Objectives (AQO) and limits
  - Familiarity with AAAQO
- Knowledge of information sources relevant to the model.
- Ability to read and understand map information.
- Ability to prepare reports and documents as necessary. Ability to review reports to ensure accuracy, clarity and completeness.
- Communication skills.
- Team skills.

## QUALITY ASSUSRANCE

- Use of standard assessment and modelling protocol.
- Selection of appropriate practitioners for the task. Referral to specialists when the situation requires specialized training.

### Tasks

- Obtain, review and interpret data from monitoring sites
- Obtain, review and interpret meteorological data
- Identify potential pollution (emission) sources and rates
  - Gather information on sources such as mass flow rates (e.g. kg of $SO_2$/hr), stack top temperature, velocity (i.e. m/s) or volumetric flow rate (e.g. cubic meters/second), and stack height and diameter
  - Calculate emission rates based on collected information
- Identify land use (urban/rural)
- Identify land cover/terrain characteristics
- Identify the receptor grid/site
- Prepare and execute dispersion model
- Interpret results of model
- Prepare reports and recommend changes based on modelling results
- Determine if further assessment is necessary

### Knowledge and Experience

- Knowledge of chemical and physical meteorology
  - Familiar with terminology, principles and interactions
  - Understanding of data collection methods and technologies
  - Ability to identify good and bad data points/sets
  - Understanding of how to deal with incomplete/missing meteorological data

- Knowledge of chemical and physical interactions of atmospheric pollutants
  - Familiarity with fate and transport of pollutants in air
  - Understanding of meteorological impacts on pollutants
  - Knowledge of primary pollutants and the synergistic effects with other substances (natural or industrial) to form secondary pollutants

- Knowledge of surface characteristics
  - Ability to identify and describe soil, water, drainage and terrain conditions
  - Understanding of their interaction
  - Familiarity with surface roughness

- Knowledge of pollution sources (point, line, area, volume)
  - Familiarity with emission control technologies
  - Knowledge of AAAQO
  - Understanding of background concentrations

- Understanding/ experience with computer modelling programs/ applications and limitations
  - Selection of model which best meets needs of the task
  - Understanding of model input parameters
  - Understanding of modelling results

- Ability to read and understand map information
  - Ability to create predicted concentration isopleths with model results